Best practices with preregistration

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My goals for this talk

- A quick introduction to what a preregistration is
- Suggest what I think are the best practices with preregistration
- Describe the benefits of preregistration (especially for early-career researchers)

The brief overview

- There is a reproducibility crisis in science – the concern that published studies do not replicate or cannot be reproduced in the first place
  - Out of 100 studies, only 29 found the same statistically significant result. (Reproducibility Project: Psychology – Open Science Collaboration, 2015)
- One cause are the preponderance of questionable research practices (QRPs) leading to a high proportion of false-positive findings (John et al., 2012)
  - Examples:
    - Stopping or continuing data collection after checking significance of results
    - Selective reporting of significant tests/omission of non-significant tests
    - Claiming to have predicted an unexpected finding (HARKing)

Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. Science, 349(6251), aac4716.
John, L. K., Loewenstein, G., & Prelec, D. (2012). Measuring the prevalence of questionable research practices with incentives for truth telling. *Psychological science*, *23*(5), 524-532.

What is preregistration?

The practice of publishing the plan for a study, including research questions/hypotheses, research design, data analysis before the data has been collected or examined.

Definition from https://forrt.org/glossary/preregistration/. Visit for a glossary of over a hundred open scholarship terms!
Parsons, S., Azevedo, F., Elsherif, M. M., Guay, S., Shahim, O. N., Govaart, G. H., ... & Aczel, B. (2022). A community-sourced glossary of open scholarship terms. *Nature human behaviour*, *6*(3), 312-318.

What is a preregistration?

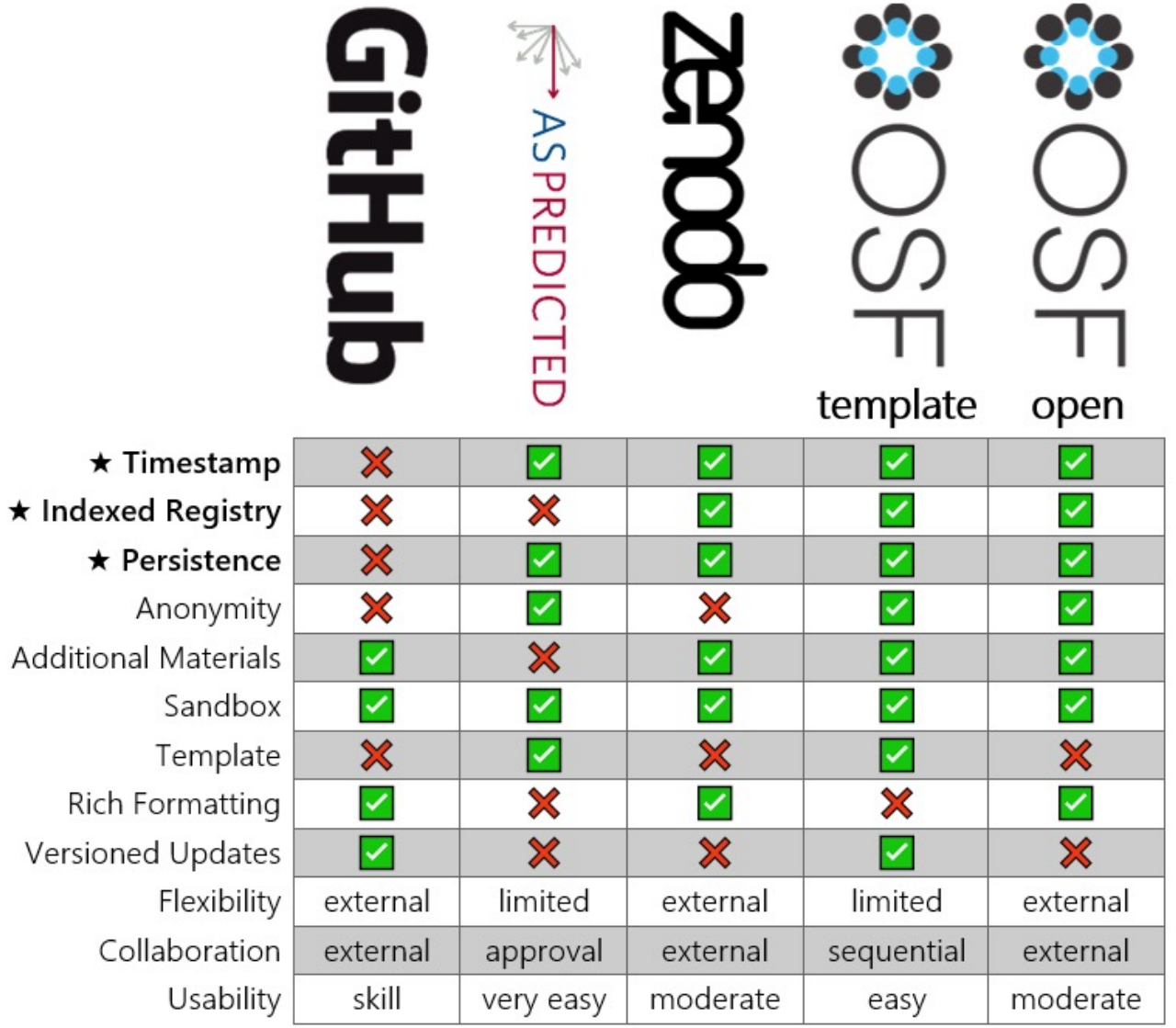
- Transparent documentation of what was planned at a certain time point

- Allows third parties to assess deviations from the research plan
  - Checking the validity of the analyses and preventing questionable research practices (QRPs) such as *p*-hacking and HARKing

Choosing a registry

- The preregistration template hosted by the Open Science Framework is a great place to start
  - Timestamped, indexed and persistent

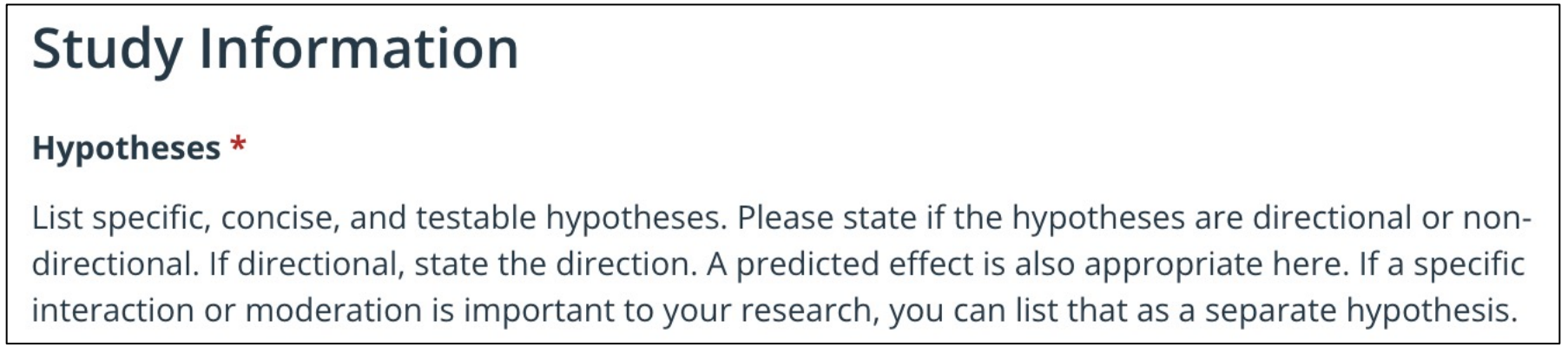
- See Haroz (2022) for a comparison of platforms and useful tips!



	GitHub	AsPredicted	Zenodo	OSF template	OSF open
★ Timestamp	✗	✓	✓	✓	✓
★ Indexed Registry	✗	✗	✓	✓	✓
★ Persistence	✗	✓	✓	✓	✓
Anonymity	✗	✓	✗	✓	✓
Additional Materials	✓	✗	✓	✓	✓
Sandbox	✓	✓	✓	✓	✓
Template	✗	✓	✗	✓	✗
Rich Formatting	✓	✗	✓	✗	✓
Versioned Updates	✓	✗	✗	✓	✗
Flexibility	external	limited	external	limited	external
Collaboration	external	approval	external	sequential	external
Usability	skill	very easy	moderate	easy	moderate

Figure from Haroz, S. (2022). Comparison of Preregistration Platforms. https://osf.io/preprints/metaarxiv/zry2u

Best preregistration practices – Hypotheses



Study Information

Hypotheses *

List specific, concise, and testable hypotheses. Please state if the hypotheses are directional or non-directional. If directional, state the direction. A predicted effect is also appropriate here. If a specific interaction or moderation is important to your research, you can list that as a separate hypothesis.

- Think about whether your work is exploratory (outcome-dependent) or confirmatory (outcome-independent)
  - Is hypothesis-testing appropriate?
- Justify your hypotheses
  - Specify the theories and formal models that make predictions about the effect
  - Indicate what will constitute evidence for or against the theories
  - Use unambiguous language

OSF Preregistration hosted at https://osf.io/registries/

Best preregistration practices – Data collection

Data collection procedures *

Please describe the process by which you will collect your data and your inclusion and exclusion criteria. If you are using human subjects, this should include the population from which you obtain subjects, recruitment efforts, payment for participation, how subjects will be selected for eligibility from the initial pool, and your study timeline. For studies that don't include human subjects, include information about how you will collect samples, duration of data gathering efforts, source or location of samples, or batch numbers you will use.

- Pilot your experimental procedures
- State **all** measured variables
- Include the experimental code
  - Have the code reviewed for readability and reproducibility
- Be clear about data handling and cleaning procedures
  - Specify any data exclusion procedures and treatment of missing values and outliers

OSF Preregistration hosted at https://osf.io/registries/

Best preregistration practices – Sample size

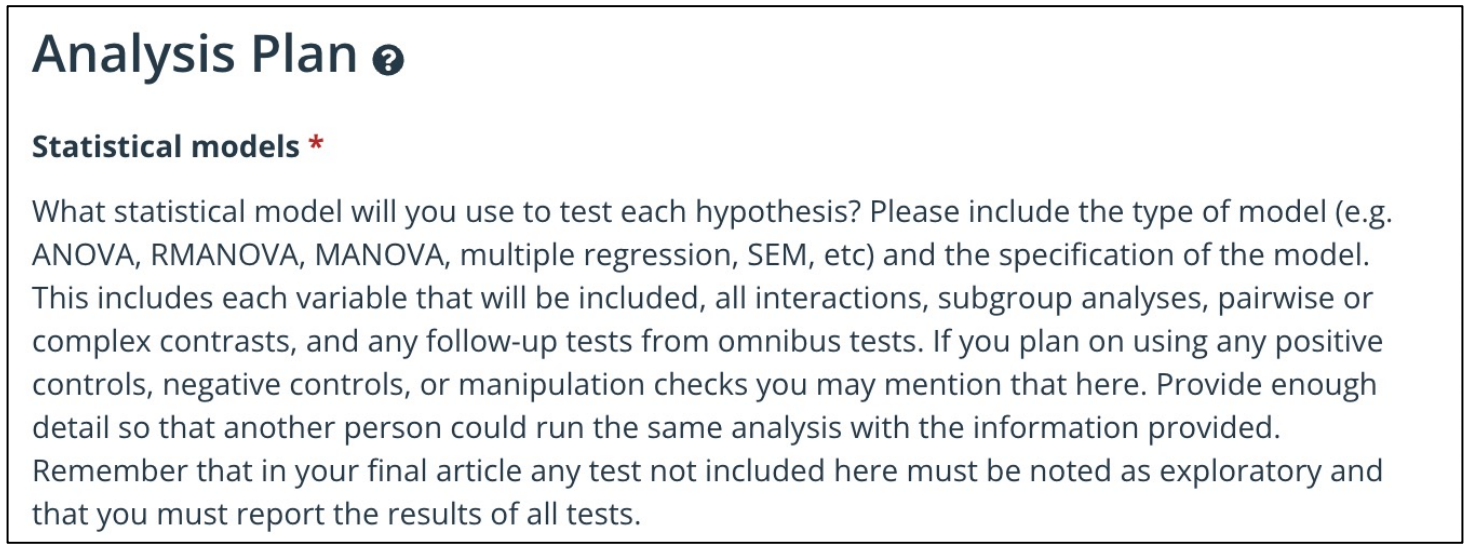
Sample size *

Describe the sample size of your study. How many units will be analyzed in the study? This could be the number of people, birds, classrooms, plots, or countries included. If the units are not individuals, then describe the size requirements for each unit. If you are using a clustered or multilevel design, describe how many units are you collecting at each level of the analysis. This might be the number of samples or a range, minimum, or maximum.

- Provide justifications for your sample size and number of trials
  - Estimate statistical power for the critical effect or test
    - NB: Power for the overall main effect is not the same for the interaction!
- Include a justified stopping rule/endpoint
  - Can simply be a date when the experiment needs to be completed by

OSF Preregistration hosted at https://osf.io/registries/
Lakens, D. (2022). Sample size justification. Collabra: Psychology, 8(1), 33267.

Best preregistration practices – Analysis plan



Analysis Plan

Statistical models *

What statistical model will you use to test each hypothesis? Please include the type of model (e.g. ANOVA, RMANOVA, MANOVA, multiple regression, SEM, etc) and the specification of the model. This includes each variable that will be included, all interactions, subgroup analyses, pairwise or complex contrasts, and any follow-up tests from omnibus tests. If you plan on using any positive controls, negative controls, or manipulation checks you may mention that here. Provide enough detail so that another person could run the same analysis with the information provided. Remember that in your final article any test not included here must be noted as exploratory and that you must report the results of all tests.

- Conduct analysis on simulated or pilot data prior to preregistration
  - Can inform your power analysis
  - Share and upload analysis code
- Include all specific analyses that are planned
  - New analyses after the data is collected is fine so long as that is made transparent in the manuscript

OSF Preregistration hosted at https://osf.io/registries/

NB: Preregistration ≠ 'good science'

- Preregistration is not sufficient to produce robust and reliable research
- Preregistration is not necessary to produce robust and reliable research

- Example:
  - One could preregister a simple *t*-test in one condition predicting an effect.
  - One could preregister a simple *t*-test in another condition predicting no effect.
  - One could then incorrectly interpret this as a significant moderation of the effect across conditions.

Preregistration is not a panacea

- Not the most efficient method to slow researchers down and improve experimental design

- Probably not a good hallmark of rigorous and reproducible research
  - But preliminary evidence that preregistration reduces the proportion of 'positive' results (~66% compared to 96% in standard papers; Akker, 2021)

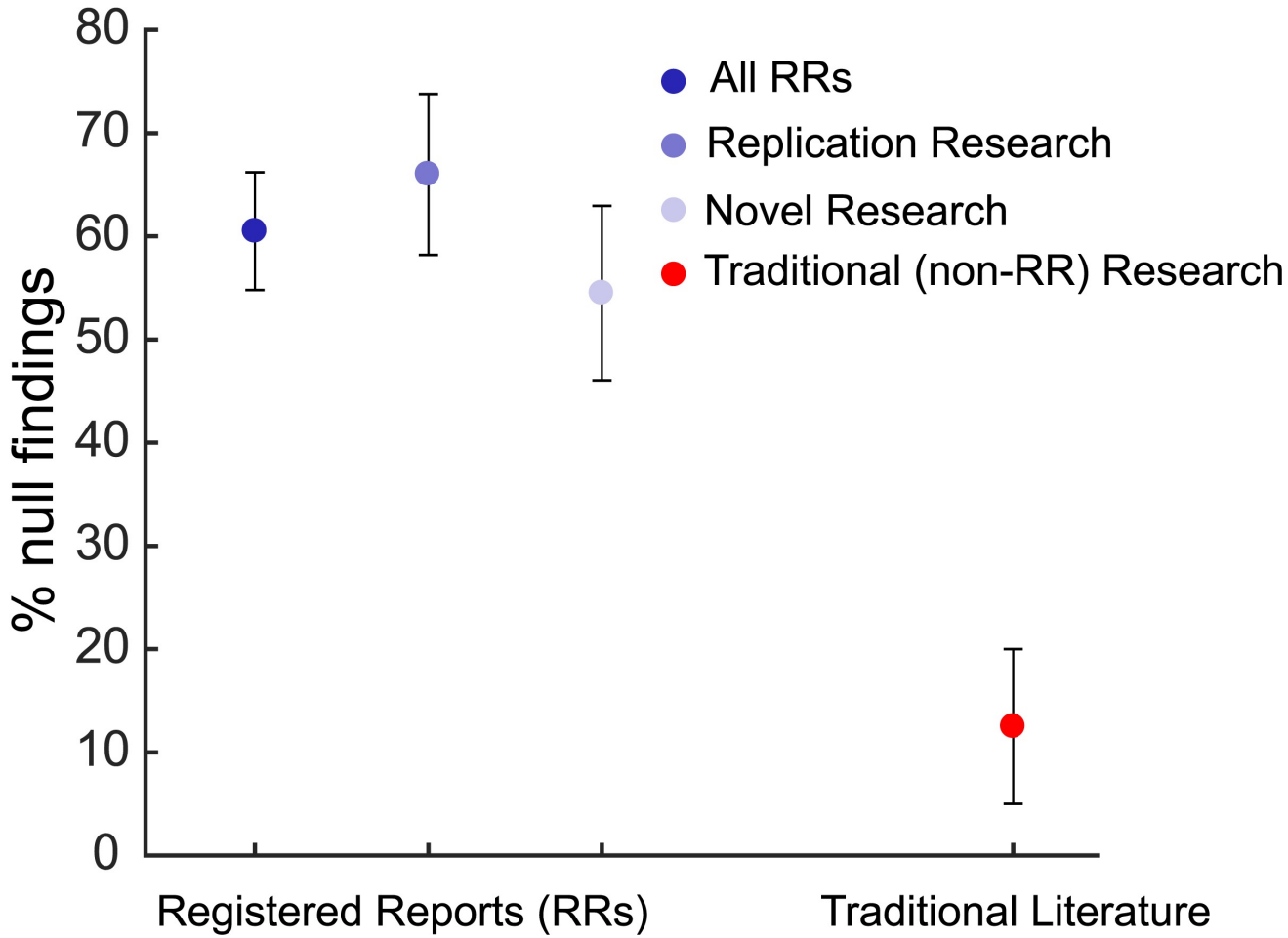
Szollosi, A., Kellen, D., Navarro, D., Shiffrin, R., van Rooij, I., Van Zandt, T., & Donkin, C. (2019). Preregistration is redundant, at best. *PsyArXiv. doi*, *10*.
Akker, O. (2021). The effectiveness of preregistration in psychology. *Presentation at Metascience 2021 conference.* https://osf.io/vpe67/

Registered Reports (RRs)

- Stage 1: A research plan (preregistration) is reviewed prior to data collection
  - Reduces research waste – addresses potential mistakes or unconsidered decisions
  - Addresses reviewer requests for additional experiments

- Stage 2: Peer review of the research manuscript (accepted publication-in-principle)
  - Addresses publication bias/the ‘file drawer problem’ – that significant results are more likely to be accepted for publication, and perceived as more impactful for higher-tier journals.

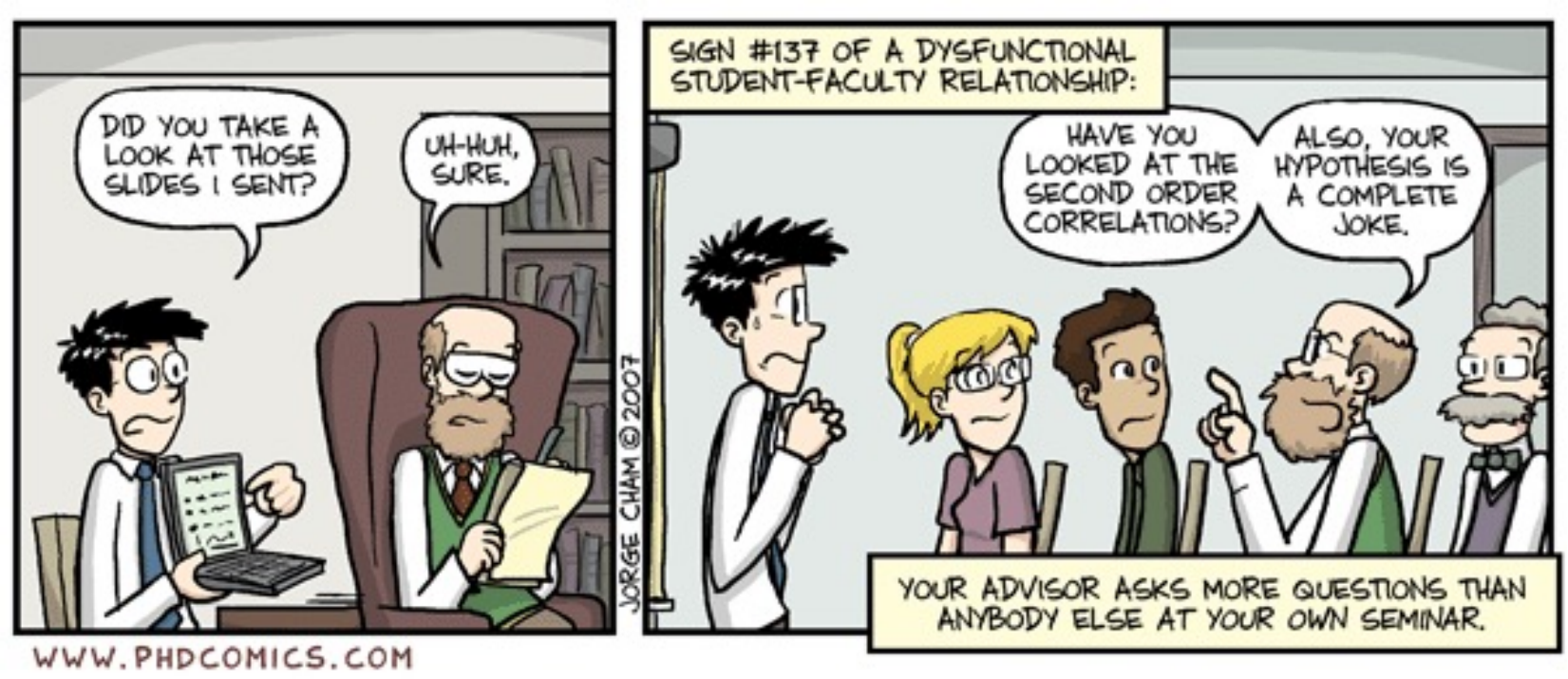
Percentage of null findings



Allen, C., & Mehler, D. M. (2019). Open science challenges, benefits and tips in early career and beyond. *PLoS biology*, *17*(5), e3000246.

Benefits of preregistration for ECRs

- A good framework for communicating and discussing experimental design with your supervisor and collaborators
  - A record of the experiment design and analysis decisions and the reasons for them
    - Answering a reviewer (or a forgetful PI) who may ask “Why did you do this?”



Comic strip from https://phdcomics.com/comics/archive_print.php?comicid=935. "Piled Higher and Deeper" by Jorge Cham www.phdcomics.com

Benefits of preregistration for ECRs

- Brings review and feedback to an earlier stage in the research process
  - Can initiate illuminating discussions (perhaps arguments!) about theory or experiment rationale

- Prevents research waste
  - Encourages a justified sample size calculation
  - Increases likelihood of publishing (especially with a negative result)
  - Reduces chance of erroneous experiments

Comic strip from https://phdcomics.com/comics/archive_print.php?comicid=935. "Piled Higher and Deeper" by Jorge Cham www.phdcomics.com

Benefits of preregistration for ECRs

- Can accompany writing experimental and analysis code
  - Encourages code review and reproducibility

- Is helpful with the writing process
  - Essentially the methods section of a paper already written!

Summary

- Preregistration can be a useful tool for improving the quality of your research
  - Inform the preregistration with formal theories, pilot studies, power analysis and reproducible code
  - A good framework to discuss and agree upon research decisions between collaborators
  - Receive external feedback of your experimental design to prevent research waste
  - Increase credibility of research during peer review

These slides will be available at https://williamngiam.github.io/

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Benefits of preregistration for vision scientists

- Registering and justification for smaller sample sizes
  - Useful for reviewers from external fields
  - Templates are being made for small-N studies (SIPS: McIntyre and Holcombe)
  - Preregistration template for EEG submitted to the Centre for Open Science (SIPS: Paul)

- Promotes confirmatory and replication studies

Potential barriers to preregistration

- Additional time cost from extra step in research workflow
  - But time saved in preventing research mistakes
  - Time saved in writing – the methods essentially already written!
  - Analysis code could be ready for when the data comes in!

- An additional venue for scrutiny of errors
  - But ideally, this is caught prior to data being collected and responsibility is shared amongst all collaborators
  - And a culture of taking responsibility for errors should be applauded

- Being locked in to a research plan
  - Deviations of preregistration are allowed! As long as that is made clear in the manuscript